

SPECIFICATION

AL2011

M775B

1 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

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Mechanical Engineering

June 9, 1992

TITLE

CHECKED BY Kurt Kennedy *KK*

Light Source - Beamlines
Vacuum Systems - General

Fabrication, Cleaning, and Certification of Stainless Steel Vacuum Chambers and Weldments for UHV:**1. Scope**

These specifications apply to Type 304, Type 304L, and Type 347 Stainless Steel vacuum chambers and welded assemblies for applications on beamlines at the Advanced Light Source, for operation at ultra-high vacuum (UHV) pressures as low as 1×10^{-10} Torr. It covers the requirements for cleaning, welding, stress-relief annealing, leak testing, certification, and preparation for shipment.

1.1 When required, stress-relief annealing after welding (per Section 4.) will be specified on fabrication drawings or other procurement documents, with supplementary information regarding any parts that must be assembled and welded after heat treatment.

1.2 When required, qualification for UHV service (per Section 6.) will be specified on fabrication drawings or other procurement documents, with supplementary information for final acceptance procedures.

1.3 Table of Contents

1. Scope
2. Cleaning and Handling
3. Welding
4. Stress-Relief Annealing After Welding
- 4A. Fabrication Operations After Welding and Bakeout for Final Cleaning
5. Leak Testing and Certification
6. Qualification for UHV Service
7. Preparation for Shipment and Delivery
8. Exceptions to This Specification
9. Quality Assurance
10. Leak Test Certification Form
11. UHV Qualification Certification Form
12. Fabrication and Assembly Documentation
13. Revision List

SPECIFICATION

AL2011

M775B

2 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

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Mechanical Engineering

June 9, 1992

2. Cleaning and Handling**2.1 General requirements for all parts and assemblies**

A. For service in a UHV environment, extreme care must be taken to avoid surface contamination of finished parts and assemblies. Avoid using any contaminating materials that cannot be cleaned using conventional procedures, and avoid contact with parts, tools, or surfaces that may result in contamination.

B. The fabricator must notify LBL if there are any questionable materials that might cause UHV contamination problems, in order to alert LBL that special cleaning procedures may be needed.

C. Any parts that need rework or repair due to mistakes or damage (such as welded plugs to fill voids and incorrectly placed holes, or bending and straightening for alignment purposes) must have approval from an authorized LBL representative prior to continuing with the work..

D. The knife-edge sealing surface on CF flanges must be protected from damage. Any scratches, dings, dents, etc. at the knife-edge will require rework and/or replacing the flange to achieve a leak-tight seal.

E. After final cleaning, handle parts with clean, lint-free gloves or cloth from that point on to prevent contamination from fingerprints. Avoid contact with any parts or tools that are not similarly cleaned for UHV.

F. After cleaning, wrap or cover individual parts with new, organic-free aluminum foil or clean, lint-free paper, and store parts in a clean, contamination-free environment.

G. Caution: Welded sub-assemblies must not be cleaned using acids, solvents or cleaning fluids that might remain trapped in crevices, particularly any active materials that may etch, corrode, or damage the chamber over time or during elevated temperatures for normal bakeouts. Clean all parts before welding, maintain cleanliness and prevent contamination during subsequent operations.

2.2 Machining Restrictions

A. Use of sulfur-bearing or silicone-bearing oils, lubricants, or coolants is prohibited.

B. Use of power-driven, resin-bonded or rubber-bonded abrasives is prohibited. Ceramic-bonded abrasives, tungsten carbide and diamond wheels are acceptable.

2.3 Cleaning for parts with fully-machined surfaces, which are NOT to be stress-relief annealed after welding

Before welding, parts must be cleaned using the following sequence:

- A. Vapor degrease using 1,1,1-Trichloroethane or other chlorinated hydrocarbon degreasing solvents.
- B. Soak in Wyandotte Diversey 909 at 180°F for 15 minutes. Alternate high-pH alkaline cleaners may be acceptable with prior approval by LBL.
- C. Immersion rinse in cold tap water.
- D. Soak in Mirachem 100 at 110°F for 5 to 10 minutes, then withdraw and check for sheeting on all surfaces. If sheeting does not occur, scrub with a wet brush using Mirachem 100. Repeat this process until sheeting occurs on all surfaces of the part. Handle with clean gloves from this point on to prevent contamination from fingerprints.
- E. Immersion rinse in cold tap water.
- F. Immersion rinse in cold de-ionized water.
- G. Immersion rinse in 150°F de-ionized water for 2 minutes. Maintain a minimum resistivity of 1×10^6 Ohm-cm.
- H. Blow dry with clean, oil-free nitrogen, argon, or air.

SPECIFICATION

AL2011

M775B

4 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

2.4 Cleaning for parts with stock surfaces or questionable surfaces, which are NOT to be stress-relief annealed after welding**Before welding**, parts must be cleaned using the following sequence:

A. Vapor degrease using 1,1,1-Trichloroethane or other chlorinated hydrocarbon degreasing solvents.

B. Soak in a high-pH alkaline cleaner at 180F to 200F for 15 minutes or until the solution completely sheets on all surfaces.

C. Immersion rinse in cold tap water.

D. Immerse in a stainless steel pickling bath with the following composition:

1 part 42% Baume Nitric acid

1 part 48% Hydrofluoric Acid

1 part de-ionized water

for 5 to 10 minutes at room temperature. Immersion time shall be sufficient to clean surface of scale and oxide. Care must be taken to avoid over-etching. Parts may be brushed with a stainless steel brush to facilitate oxide removal.

Handle with clean gloves from this point on to prevent contamination from fingerprints.

E. Immersion rinse in cold tap water. Check for sheeting on all surfaces. If sheeting does not occur, repeat the cleaning process until sheeting occurs on all surfaces of the part.

F. Immersion rinse in 150°F de-ionized water for 2 minutes. Maintain a minimum resistivity of 1×10^6 Ohm-cm.

H. Blow dry with clean, oil-free nitrogen, argon, or air.

SPECIFICATION

AL2011

M775B

5 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

2.5 Alternate cleaning for welded metal bellows with stock surfaces, which are NOT to be stress-relief annealed after welding

NOTE: This cleaning procedure may be used as an alternate procedure for Section 2.4 for welded metal bellows for which stock surfaces can be adequately cleaned without acid-etch processes. Written authorization by LBL is required if this cleaning procedure is used for any other stock surfaces or questionable surfaces intended for UHV applications.

Before welding, parts must be cleaned using the following sequence:

A. Vapor degrease using 1,1,1-Trichloroethane or other chlorinated hydrocarbon degreasing solvents.

B. Immersion rinse in cold tap water.

C. Immersion rinse in *Synasol 190*.

Chemical composition of *Synasol 190* is:

Ethanol 92%

Methanol 5%

Ethyl Acetate 1%

Aliphatic Hydrocarbons 1%

Methyl Isobutyl Ketone 1%

Handle with clean gloves from this point on to prevent contamination from fingerprints.

D. Immersion rinse in cold tap water. Check for sheeting on all surfaces. If sheeting does not occur, repeat the cleaning process until sheeting occurs on all surfaces of the part.

E. Immersion rinse in 150°F de-ionized water for 2 minutes. Maintain a minimum resistivity of 1×10^6 Ohm-cm.

F. Blow dry with clean, oil-free nitrogen, argon, or air.

SPECIFICATION

AL2011

M775B

6 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

2.6 Cleaning for parts which are to be stress-relief annealed after welding (per Sect. 4) or parts that will receive a high-temperature bakeout (per Sect. 4A)

A. **Before welding**, vapor degrease all parts using 1,1,1-Trichloroethane or other chlorinated hydrocarbon degreasing solvents.

B. After degreasing, avoid contact with parts or tools that have not been similarly cleaned to prevent contamination with oils, lubricants, etc.

SPECIFICATION

AL2011

M775B

7 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

2.7 Electropolishing as an alternate cleaning process for stock surfaces or questionable surfaces, which are **NOT** to be stress-relief annealed after welding

NOTE: This cleaning procedure may be used as an alternate for applications where chemical cleaning per Section 2.4 is inappropriate or not economically feasible. All electropolishing is subject to written authorization by LBL to confirm that the electropolishing configurations, electrode arrangements, current densities, masking, material removal, rinsing processes, etc. are acceptable.

The following electropolishing sequence is a general guideline for electropolishing, subject to LBL approval for any specific application. (A similar procedure may be used after welding.)

Before welding, parts must be cleaned using the following sequence:

- A. Vapor degrease using 1,1,1-Trichloroethane or other chlorinated hydrocarbon degreasing solvents.
- B. Immersion rinse in cold tap water.
- C. All conflat knife-edge surfaces (and other surfaces if specified) must be masked, typically using 3M high heat resistant plater's tape, to protect these edges from the full electropolishing process.
- D. Fully electropolish the part according to approved procedures, typically (for most vacuum chambers) to remove 0.0002 to 0.0005" surface layer. The entire part must be completely immersed in the electropolishing tank. No tipping or rotating to achieve coverage.
- E. Immersion rinse in nitric acid, then immersion rinse in cold tap water.
- F. Remove masking materials.
- G. Lightly electropolish (without masking) for 15 to 20 seconds for final cleaning of the previously masked surfaces.
- H. Immersion rinse in nitric acid, then immersion rinse in cold tap water.
- I. Scrub all surfaces with a clean, new, wet Tampico brush, then immersion rinse in cold tap water.

SPECIFICATION

AL2011

M775B

8 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaroMechanical EngineeringJune 9, 1992

J. Check for sheeting on all surfaces. If sheeting does not occur, repeat cleaning steps H & I until sheeting occurs on all surfaces of the part.

K. Immersion rinse in 150°F de-ionized water for 2 minutes. Maintain a minimum resistivity of 1×10^6 Ohm-cm.

L. Blow dry with clean, oil-free nitrogen, argon, or air.

SPECIFICATION

AL2011

M775B

9 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

3. Welding

3.1 Welding is to be done using gas tungsten-arc welding (GTAW) process, with 99.99% pure Helium or Argon, or certified minimum impurity (99.99%) Argon-Helium mixtures. (Alternately, electron beam welding is acceptable, as required.)

3.2 Welding is to be done in a cleanroom environment.

3.3 Before welding, all parts, filler rod, and surfaces are to be cleaned per Section 2.

3.4. Where welds on the external surface of the vacuum component are required, the internal (vacuum) surface in the weld zone shall be provided with an inert atmosphere equal in quality to that of the arc shielded gas.

3.5 Weld appearance must be smooth with a transparent, white to light golden straw color.

3.6 All welds at vacuum surfaces are to be left in as-welded condition. No power-driven abrasives or brushes are permitted. Manual cleaning may be done using a new, clean, stainless steel "toothbrush" to remove oxidation.

3.7 All metal removal of defective welds shall be performed with tungsten carbide rotary files. The defective area shall be removed along with adequate sound weld metal on both sides of the defect before repeating the weld.

3.8 All welds are to be in conformance with appropriate AWS standards and generally accepted welding practice for vacuum vessels for UHV service. Where required, filler material shall be clean Type 308 stainless steel. Whenever appropriate, welding shall conform to ANSI/AWS D10.4, "Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing."

3.9 Unless specified, all welded joints on surfaces exposed to vacuum must be continuous fusion welds with no filler material. External, structural welds must not be continuous, to allow for direct leak-checking of all air-to-vacuum joints.

3.10 When requested, the seller must provide LBL with a copy of weld procedures to be used, or describe the seller's normal fabrication and assembly practice, subject to final acceptance by LBL.

SPECIFICATION

AL2011

M775B

10 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaroMechanical EngineeringJune 9, 1992**4. Stress-Relief Annealing After Welding**

4.1 When stress-relief annealing is specified on fabrication drawings or other procurement documents, heat treatment must be done in an argon furnace, vacuum furnace, or hydrogen furnace at 1650°F to 1830°F (900°C to 1000°C) for 2 hours, unless otherwise specified. Furnace cool or quench with clean, dry inert gas.

4.2 After heat treatment, parts must show no discoloration. Cool in an inert gas atmosphere to below 200°F (100°C) before exposure to air to prevent any oxidation and discoloration.

4.3 LBL reserves the option to have an authorized LBL representative inspect and approve the annealing furnace and procedures.

4.4 Heat treatment certifications and data shall be provided to LBL for each assembly.

4.5 When required, LBL will request dimensional inspection and acceptance of the preliminary weldment prior to heat treatment.

SPECIFICATION

AL2011

M775B

11 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

4A. Fabrication Operations After Welding and Bakeout for Final Cleaning

4A.1. When machining or other fabrication operations are required after welding, all post-welding operations should be done preferably in a clean-room environment avoiding contact with any coolants, cutting fluids, tools or materials that may cause UHV contamination. (Note, alcohol may be used as a cutting fluid if required.)

4A.2 When specifically permitted per fabrication drawings or other documentation, non-clean room fabrication operations with potential contaminants may be used. Final cleaning must be done with a high-temperature bakeout before assembly and installation for UHV service.

4A.3 Before bakeout, weldments may be cleaned using 1,1,1-Trichloroethane or other chlorinated hydrocarbon degreasing solvents, steam-cleaning, or other procedures for specific applications. The cleaning procedures that are used must be approved by an authorized LBL representative prior to these operations.

4A.4 When bakeout for final cleaning is specified on fabrication drawings or other procurement documents, bakeout must be done in an argon furnace, vacuum furnace, or hydrogen furnace with the weldment held at 575°F to 750°F (300°C to 400°C) for 2 hours, unless otherwise specified. Furnace cool or quench with clean, dry inert gas.

4A.5 After bakeout, parts must show no discoloration. Cool in an inert gas atmosphere to below 200°F (100°C) before exposure to air to prevent any oxidation and discoloration.

4A.6 When required, LBL will request dimensional inspection and acceptance of the weldment and post-welding operations prior to bakeout.

4A.7 LBL reserves the option to have an authorized LBL representative inspect and approve the bakeout furnace and procedures.

4A.8 Cleaning procedures, bakeout temperature cycle and duration data shall be provided to LBL for each assembly.

SPECIFICATION

AL2011

M775B

12 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaroMechanical EngineeringJune 9, 1992

5. Leak Testing and Certification

5.1 Unless otherwise specified, the final assembly must be leak-tight for UHV service, using standard copper gaskets on all cf flanges, with total leak rate less than 1×10^{-9} std atm cc/sec, having the assembly "bagged" in at least 50% helium atmosphere for at least 2 minutes. Use a LN-trapped arrangement to prevent backstreaming contamination from the leak detector.

5.2 The recommended leak checking procedures are per ASTM E498, "Standard Methods of Testing for Leaks Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Tracer Probe Mode."

5.3 The leak detector must be properly calibrated for sensitivity in the range of 2×10^{-10} std atm cc/sec. The recommended calibration procedures are per ASTM F78, "Standard Method for Calibration of Helium Leak Detectors by use of Secondary Standards," using an additional calibrated leak having a leak rate of approximately 2×10^{-10} std atm cc/sec.

5.4 LBL reserves the option to have an authorized LBL representative witness the calibration and leak checking procedures.

SPECIFICATION

AL2011

M775B

13 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaroMechanical EngineeringJune 9, 1992**6. Qualification for UHV Service**

When specified on fabrication drawings or other procurement documents, the final assembly must be qualified for UHV service by the following:

- 6.1 Using a prescribed configuration and procedures for assembly and bakeout, achieve a base pressure of 5×10^{-10} Torr (unless otherwise specified) or lower, at room temperature, within 5 days following venting to atmosphere. The base pressure is to be measured using an ion gauge.
- 6.2 The ion gauge controller must be properly calibrated. When requested, the seller must provide LBL with a description of the calibration procedures used.
- 6.3 Certify Residual Gas Analysis indicating that the predominant component is hydrogen, contributing at least 60% to the total pressure, and no mass peak above mass number 46 shall be greater than 1×10^{-12} Torr. Prior to shipment, provide LBL with a hard copy printout of the RGA scan, certified for each assembly.
- 6.4 The RGA system must be properly calibrated. When requested, the seller must provide LBL with a description of the calibration procedures used. LBL reserves the right to verify the RGA calibration using a known gas sample. Upon request, LBL will provide a known gas sample for testing.
- 6.5 When required, LBL may request dimensional inspection, leak-checking and preliminary acceptance of the parts and/or assemblies prior to final cleaning and bakeout procedures.
- 6.6 After qualification, the assembly must be back-filled with clean, dry nitrogen (liquid nitrogen boil-off) at atmospheric pressure, or internal pressure not to exceed 5 psig.
- 6.7 LBL reserves the option to have an authorized LBL representative witness any bakeout, calibration, and qualification procedures.

SPECIFICATION

AL2011

M775B

14 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaroMechanical EngineeringJune 9, 1992

7. Preparation for Shipment and Delivery

7.1 Cleaned surfaces must not be exposed to any contaminants. Packaging must insure acceptance and safe delivery by common or other carrier, so that the product can be delivered in an undamaged condition. Appropriate packaging is the responsibility of the seller, unless otherwise provided or specified by LBL.

8. Exceptions to this Specification

8.1 Exceptions or changes to this specification may be required according to fabrication drawings or other procurement documents for a designated part or assembly, which will take precedence over the specifications in this document. If there is an apparent conflict among specifications, an authorized LBL technical contact will make the final determination as to which document takes precedence.

8.2 LBL encourages the seller to recommend alternate fabrication methods or design changes that might improve the quality of the finished product, reduce costs, etc., **TO BE IMPLEMENTED ONLY WITH PRIOR, WRITTEN LBL APPROVAL AND FORMAL CHANGE AUTHORIZATION** via appropriate channels in the LBL Purchasing Department.

9. Quality Assurance

9.1 Components and final assembly shall conform to all specifications and drawings which have been approved for fabrication prior to shipment. LBL reserves the right to inspect all of the items for conformance to the specifications and drawings, and reject any items that do not meet the requirements of the drawings, specifications, and procurement documents.

9.2 The seller shall notify LBL immediately for review and approval for any fabrication discrepancies, fabrication changes, changes in documented schedules or other commitments according to the purchase order.

9.3 LBL reserves the right to visit the seller, upon reasonable prior notice, to review progress of the manufacturing process.

SPECIFICATION

AL2011

M775B

15 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaro

Mechanical Engineering

June 9, 1992

10. Appendix A: Leak Test Certification Form

LBL Purchase Order or Job Order _____ Date: _____

Drawing Number(s): _____

Assembly or Part Name: _____

Manufacturer/Fabricator/Shop: _____

The above named fabricator certifies that this part or assembly was fabricated, cleaned, and tested in accordance with LBL Specification M775 and supplementary specifications on the fabrication drawings and procurement documents.

Mfg. Representative Name: _____ Title: _____

Vacuum Leak Test Certification:

Testing Company or Organization: _____

Leak Detector Mfg.: _____ Model: _____ Serial #: _____

Minimum detectable leak rate: _____

Calibration:

(1) Calibrated Leak Mfg.: _____ Type: _____ Serial #: _____

Helium Standard Leak Rate: _____ Date Calibrated _____

(2) Calibrated Leak Mfg.: _____ Type: _____ Serial #: _____

Helium Standard Leak Rate: _____ Date Calibrated _____

Leak Test Results:

Detected Helium Leak Rate: _____ Pressure: _____

Remarks: _____

Signatures: Leak Tested by _____ Date: _____

Mfg. Representative: _____ Date: _____

SPECIFICATION

AL2011

M775B

16 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE

Dick DiGennaroMechanical EngineeringJune 9, 1992**11. Appendix B: UHV Qualification Test Certification Form**

LBL Purchase Order or Job Order _____ Date: _____

Drawing Number(s): _____

Assembly or Part Name: _____

Manufacturer/Fabricator/Shop: _____

The above named fabricator certifies that this part or assembly was fabricated, cleaned, and tested in accordance with LBL Specification M775 and supplementary specifications on the fabrication drawings and procurement documents.

Mfg. Representative Name: _____ Title: _____

UHV Qualification Test Certification: (Attach hard copy printout of RGA scan)

Testing Company or Organization: _____

RGA Mfg.: _____ Model: _____ Serial #: _____

Date of RGA Calibration: _____

Ion Gauge Mfg.: _____ Model: _____ Serial #: _____

Final Base Pressure: _____ Date: _____

Brief Description of Cleaning/Bakeout Procedures, and Additional Remarks:

Signatures: Leak Tested by _____ Date: _____

Mfg. Representative: _____ Date: _____

Additional Remarks, Special Handling, Re-work Description, Problems, etc.
(Attach additional notes if required)

SPECIFICATION

AL2011

M775B

18 OF 18

AUTHOR

DEPARTMENT

LSME 500B

DATE _____

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Mechanical Engineering

June 9, 1992

13 Revision List

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